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Beet Leafhopper Control

IN WEED-HOST AREAS OF IDAHO TO PROTECT SNAPBEAN SEED FROM CURLY TOP

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Issued July 1955

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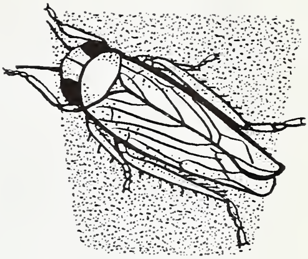
Beet Leafhopper Control



In Weed-Host Areas of Idaho to Protect Snapbean Seed From Curly Top [1, 2, 3]

By J. R. Douglass, Van E. Romney,[4] and E. W. Jones,[5] *entomologists, Entomology Research Branch, Agricultural Research Service*

The beet leafhopper (*Circulifer tenellus* (Baker)) is the only known carrier of curly top, a destructive disease of beans, sugar beets, tomatoes, cantaloups, and spinach. All commercial varieties of snapbeans are more or less susceptible to curly top. This disease is the most important factor limiting the growing of snapbeans for seed in south-central Idaho, where approximately 80 percent of the Nation's requirement of this seed is grown. About 35 million pounds of seed, valued at approximately 3½ million dollars, are produced annually on about 30 thousand acres of land in Idaho.

The beet leafhopper does not reproduce on beans, but the adults infect the young plants when they feed on them as the spring migrants move from the drying spring host plants to their summer hosts. This feeding causes some reduction in yield, which varies each year with the number of leafhoppers moving to the beans, the percentage of them that carry the curly-top virus, and the development reached by the bean plants fed upon by the virus-carrying leafhoppers (fig. 1). Beans in the seedling, or crookneck, stage are the most susceptible and usually die when infected. However, plants infected when they are in a more advanced stage of growth often survive and produce stunted pods.

In 1949 a project was undertaken to develop methods for the control of the beet leafhopper in Idaho (fig. 2). The principal objective was to determine whether the snapbean seed crop could be protected from serious curly-top infection during years of heavy beet leafhopper infestation by destroying the leafhoppers in their breeding areas in the spring before they moved into the beanfields. These areas are located on idle, waste, and overgrazed lands in the south-central part of the State (fig. 3), of which approximately 78 percent is owned by the Federal Government, 7 percent by the State, and 15 percent by individuals. These areas ranged from ¼ acre to 1,000 acres or more, and were scattered over approximately 1,200 square miles.

From 1949 through 1951 this work was conducted by the U. S. Bureau of Entomology and Plant Quarantine in cooperation with the Idaho Agricultural Experiment Station, the U. S. Bureau of Land

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[1] Submitted for publication January 14, 1955.

[2] Published with the approval of the Director of the Idaho Agricultural Experiment Station as Research Paper No. 367.

[3] Report of a study in which certain phases were carried out under the Research and Marketing Act of 1946. H. C. Hallock and W. E. Peay assisted in the study.

[4] Resigned October 1951.

[5] Retired March 1952.

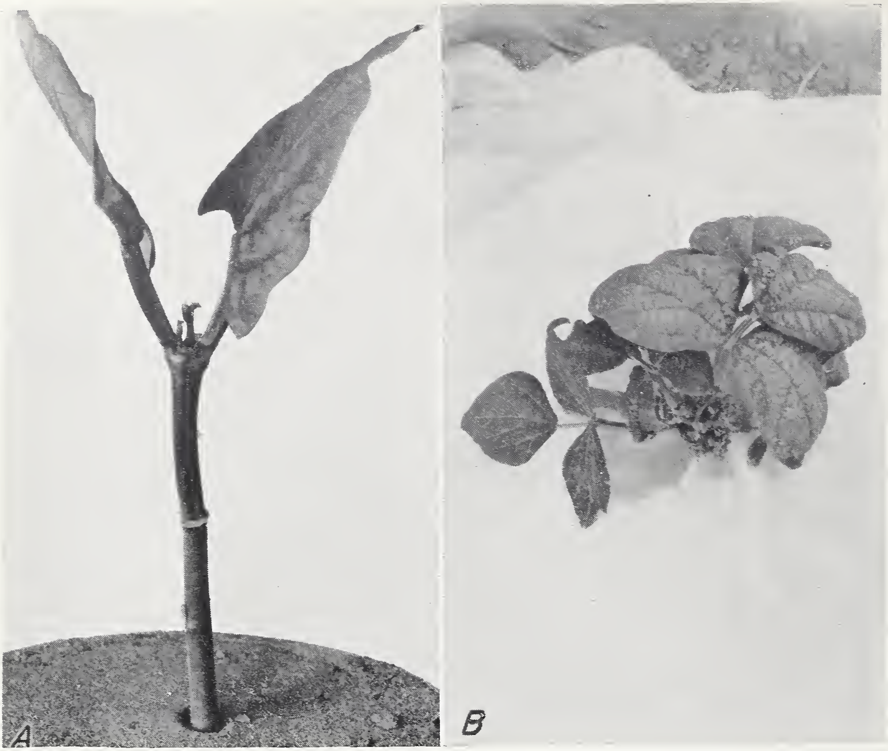

Figure 1.—Bean plants infected with curly top: *A*, In the seedling stage; *B*, in a more advanced stage of growth.

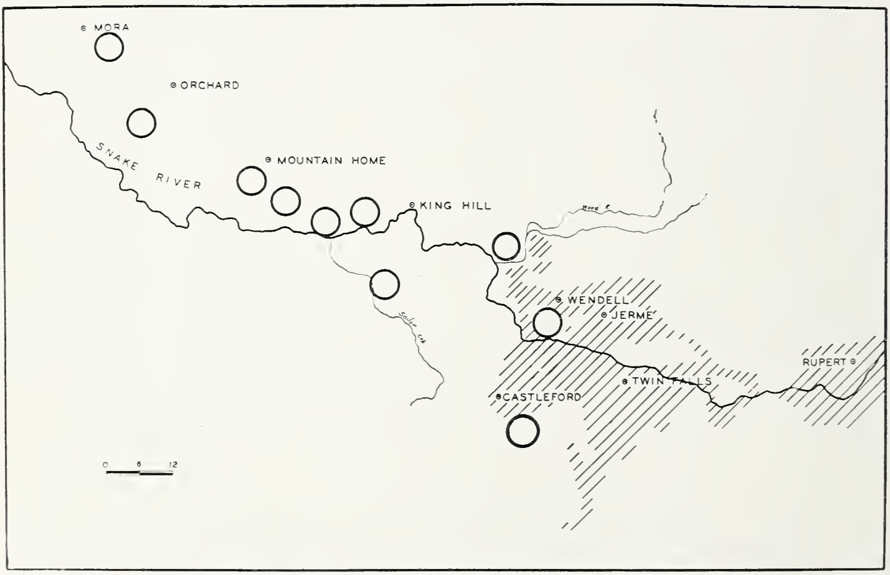

Figure 2.—Map of south-central Idaho. Diagonal lines indicate cultivated areas where snapbeans are grown for seed; circles indicate weed-host areas sprayed for beet leafhopper control.

Management, the Idaho Land Department, bean seedsmen and growers, and livestock men. No control program was conducted in 1952. In 1953 the control program was conducted with the same cooperation, but was financed jointly by the Idaho Department of Agriculture and the Bureau of Entomology and Plant Quarantine. The headquarters for this work was at Twin Falls, Idaho.

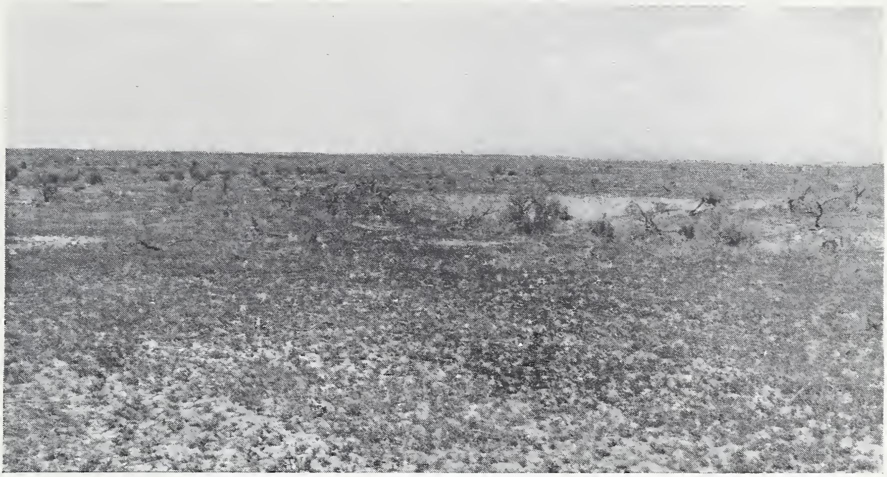

FIGURE 3.—Beet leafhopper breeding area covered with perfoliate pepperweed near Mountain Home, Idaho.

BEET LEAFHOPPER HABITS

The beet leafhopper is a sun-loving, dry-climate insect. In southern Idaho it passes the winter in the adult stage. Females are fertilized in the fall and live until spring, but males die during the winter. Egg laying normally begins in March, and adults of the first, or spring, generation appear in May or June. This generation is produced on winter annual weeds, chiefly wild mustards. Under favorable conditions the seeds of these weeds germinate in the fall but occasionally in the spring. The fall-germinated plants remain alive through the winter and complete their growth in the spring. They mature and dry about the time the spring generation of leafhoppers reach the adult, or winged, stage. When the weather is favorable for flights, these leafhoppers leave their spring hosts and move to their summer hosts. They travel with the wind and infest practically all plants in their path. It is mostly during this spring movement that beans and other susceptible crops are infected (fig. 4).

The leafhoppers moving into the cultivated areas alight first in the fields nearest their breeding grounds and gradually move farther into the cultivated lands. Consequently, during years of moderate populations heavy losses are confined to beanfields nearest the breeding grounds. Growers have taken advantage of these conditions and have grown the most susceptible varieties of beans near the middle of the cultivated areas.

The movement of the spring generation into the cultivated areas of south-central Idaho usually begins about May 24 and reaches its peak about June 22. However, most of the migrants enter the bean-

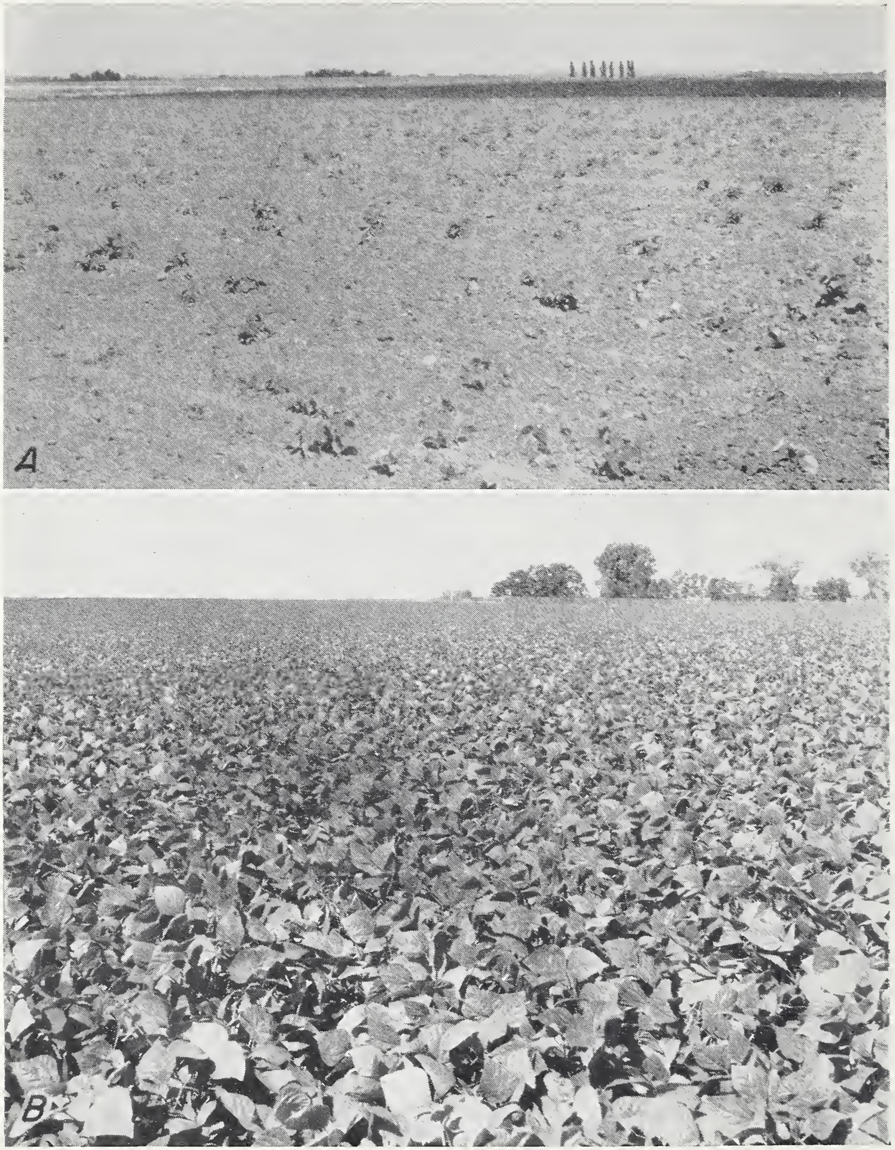

FIGURE 4.—Fields of snapbeans: *A*, Destroyed by curly top; *B*, not infected with curly top.

fields during the second and third weeks of June. The average growing season for beans and other cultivated crops is from May 16 to September 24, or 131 days. Since snapbeans require from about 90 to 110 days to reach maturity, the planting dates cannot be delayed until after the spring movement to escape infection.

The virus of curly top survives the winter in both the beet leafhopper and in its principal winter host plants. However, the percentage of the spring-generation leafhoppers carrying the virus varies from year to year. Since 1930 it has ranged from 4 to 80 percent. The beet leafhopper does not reproduce on beans and, consequently, only the adults transmit the virus of curly top to this crop. On breeding hosts, such as sugar beets and certain weeds, both the adults and their progeny function as curly-top vectors.

During the spring movement the leafhoppers begin to feed immediately after alighting upon the plant. Studies have shown that they can infect healthy plants with the virus in a feeding time of 1 minute. They have infected plants up to about 10 minutes after being exposed to DDT-treated foliage, although DDT is one of the most effective insecticides against this leafhopper. Susceptible crops are continually reinfested, so that insecticide control of the leafhopper to prevent curly-top disease is a difficult problem. Douglass and coworkers (*2*) [6] have shown that curly-top-susceptible R. and G. Old Type beets could be protected from curly-top infection by controlling the beet leafhoppers with insecticides, but that the number of insecticide applications required to protect the crop was prohibitive.

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[6] Numbers in parentheses refer to Literature Cited, p. 13.

CONTROL METHODS

Since there were no satisfactory and practical chemical methods for the control of the beet leafhopper and of curly top on cultivated crops, other methods of control have been developed.

Control of Curly Top

Curly top may be controlled by breeding resistant varieties of plants. Good examples of this method are curly top-resistant sugar beets that have been developed. Similar plant breeding is being conducted on beans by personnel of the Idaho Agricultural Experiment Station, who pioneered in the development of curly top-resistant bean varieties. They have produced several varieties of Great Northern and Pinto dry edible beans that are resistant to the disease. The bean improvement work in Idaho has for several years been carried on in cooperation with the U. S. Department of Agriculture. However, to develop resistance to curly top and other diseases in all varieties of snapbeans may require many years.

Control of the Beet Leafhopper

The beet leafhopper may be controlled by adopting range practices that will lead to the replacement of the weed hosts by perennial forage grasses that are not breeding hosts of the insect. This may best be accomplished by reseeding abandoned, overgrazed, or burned areas (fig. 5), or by protecting sparse stands of the perennial grasses against overgrazing or other destructive influences.

The identity and distribution of the major weed hosts of the beet leafhopper have been determined, and methods for their replacement by nonhost perennial grasses have been developed in cooperation with plant ecologists. However, this method will also require several years for its consummation.

The beet leafhopper may also be controlled by applying insecticides to the heavily infested weed-host areas before the leafhoppers move to cultivated crops. Armitage (*1*) has demonstrated that curly top in susceptible crops in California could be controlled by spraying infested

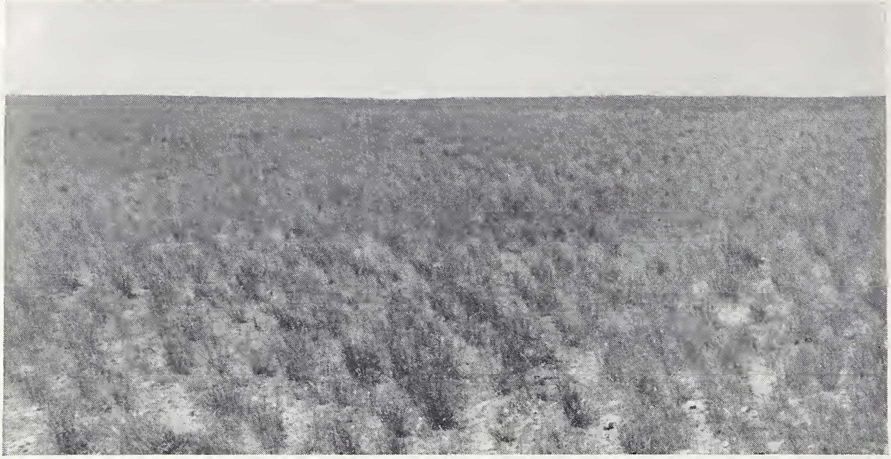

FIGURE 5.—Crested wheatgrass in southern Idaho that was planted to replace weed hosts of the beet leafhopper.

weed-host areas on open rangeland. Although the overwintered females usually congregate in large numbers during the spring in favorable parts of the breeding areas, the acreage of these areas proved to be small compared with the total acreage of the breeding areas or of susceptible crops grown on adjacent or highly productive irrigated lands nearby. Operators have taken advantage of this congregating habit when they have planned their spraying operations.

There are two periods in the spring when the beet leafhopper can be controlled by spraying its desert breeding areas—before the overwintered females have laid many eggs and after most of the spring-generation nymphs have hatched. After the winter has taken its toll of females, the population is the lowest of the year. However, unfavorable weather usually limits the time available for effective spraying. Because the nymphs are more susceptible to DDT than are the adults, less insecticide is needed to treat them than the overwintered females. The spray program was therefore directed against the nymphs.

EQUIPMENT AND PROCEDURES

During the course of planning the spraying operations against the beet leafhopper, consultations were held with officials of the California Department of Agriculture because of their experience in conducting similar work in that State. Their advice proved invaluable in the selection and purchase of the equipment used in Idaho.

Turbine blowers as delivered by the manufacturer were modified for spraying the weeds. The blowers were mounted on four-wheel-drive trucks, which could be driven over practically all the breeding areas. After the first season the manual control of the blower was placed in the cab of the truck, so that the driver could operate the blower. During the 1949 season, when pyrethrum was used, the hydraulic pump on the blowers was operated at a pressure of 150 pounds per square inch and delivered 2 gallons of spray per minute through nine spray nozzles used on the USDA air-broadcast nozzle (fig. 6). The

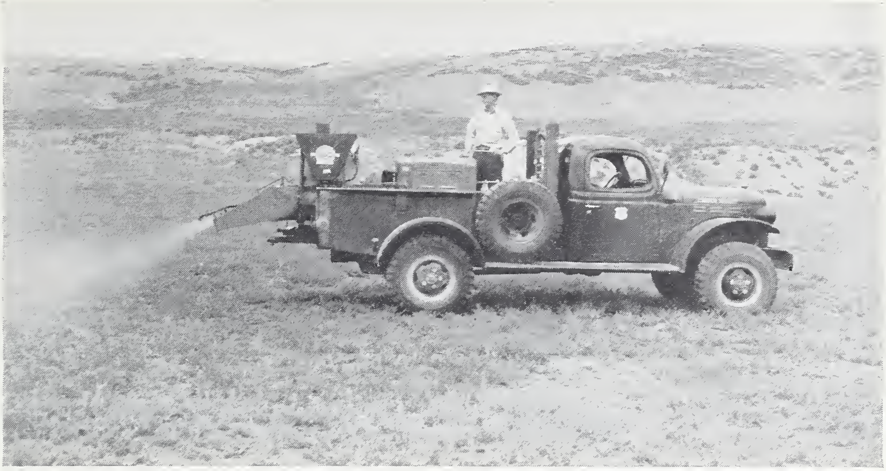

Figure 6.—Spray being applied with a turbine blower mounted on a truck and using the USDA air-broadcast nozzle.

spray was applied from the rear of the truck at the rate of 3.4 gallons per acre over a swath 30 feet wide.

In 1950, 1951, and 1953, when DDT was used, the hydraulic pump was operated at 125 pounds per square inch and delivered 3 gallons of spray per minute through four nozzles, the orifices of which had been rebored to a diameter of 0.095 inch. The throttle of the truck was set at a speed to deliver 2 gallons of spray per acre over a swath 100 feet wide (fig. 7) with the round side-delivery air nozzles. The capacity of the spray tanks (fig. 8) permitted the treatment of 50 acres before refilling.

DDT emulsion was prepared at the Twin Falls field station and transported by truck in 50-gallon drums to the areas to be sprayed. Water for the sprays was hauled by truck in 500-gallon tanks mounted on trailers (fig. 9). Each trailer was equipped with a small

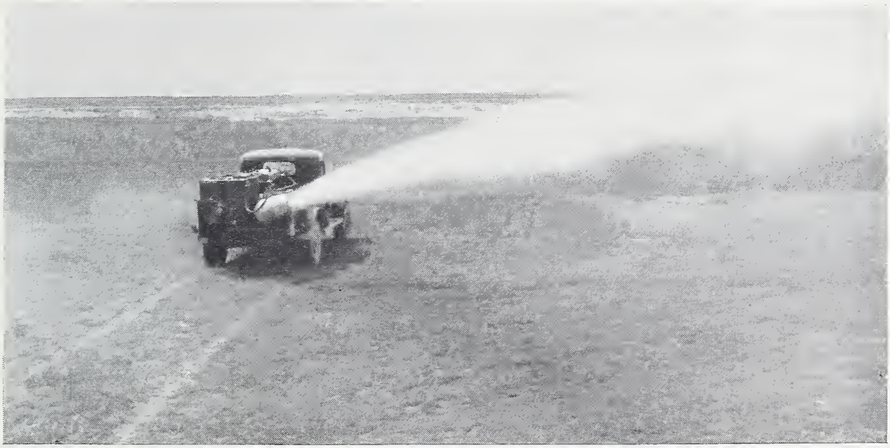

Figure 7.—Spraying a weed-host area containing high populations of beet leafhoppers. The nozzle is adjusted according to the wind velocity, so as to spray the weeds in overlapping swaths as the sprayer moves back and forth.

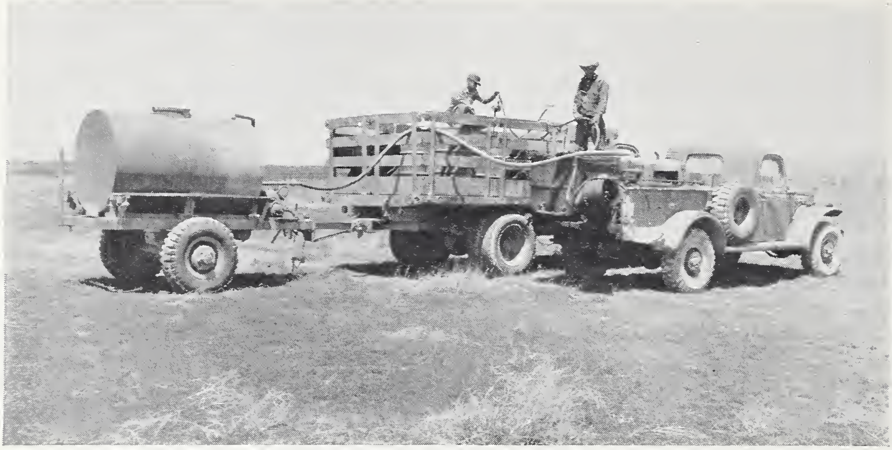

Figure 8.—Spray tanks being filled from stock emulsion and water tanks.

gasoline engine and a pump, so that the tanks could be filled from irrigation canals and other sources. Water from the large tanks was pumped into the blower spray tanks after the desired amount of DDT emulsion had been added.

In the large breeding areas flags on metal rods were placed at each end of a long run and moved over 100 feet after each run. In small weed-host areas and patches a flagman in the center of the run was able to direct the driver so that such areas could be adequately sprayed without overlapping.

Spring studies to determine the general abundance and distribution of overwintered leafhoppers were made as soon as the weather in March and April permitted. The heavily populated areas were then restudied more intensively and the weed areas containing dangerous

Figure 9.—Spray equipment along a desert trail. A typical weed-host breeding area is in the foreground.

populations were marked with flags. Only these areas were sprayed.

In the spring the prevailing wind across southern Idaho is from the west, and leafhoppers in flight move with the wind across the Snake River plains. For this reason the weed-host areas that were sprayed were within, adjoining, or to the west of the cultivated areas.

The effectiveness of the sprays was determined from pre- and post-treatment counts of beet leafhoppers in random samples of weeds. These counts were made with the aid of samplers. In small, well-spaced stands of weeds, a modification of Hills' cage sampler (*3*) was used. Where the host plants were large and dense, a ½-square-foot sampling fork described by Lawson et al. (*4*) was used. Counts were made the day the spray was applied and from 6 to 24 hours after the pyrethrum and from 4 to 7 days after the DDT treatments.

MATERIALS

Mustard plants growing on weedy rangelands form an important part of the food for sheep grazing on such areas early in the season. Because of the publicity in 1949 regarding the possibility of an accumulation of DDT in the fat particles of milk, and since ewes with suckling lambs were on the range during the spray period, it was decided to start the program with pyrethrum rather than with DDT spray.

Pyrethrum is a contact insecticide that is relatively nonpoisonous to warm-blooded animals but is effective against the beet leafhopper. The pyrethrum used contained not less than 4 grams of pyrethrins per 100 cc. It was added to a No. 2 diesel fuel oil in the ratio of 1 gallon of pyrethrum to 49 gallons of the diesel oil.

Pyrethrum has little residual effect and did not kill the nymphs that hatched after the spray was applied; therefore, after 1949 it was decided to use DDT, which has a good residual effect.

The DDT mixture used in 1950 consisted of 100 pounds of technical DDT, 27½ gallons of an alkylated naphthalene solvent, and 85 ounces of the emulsifier alkylated aryl polyether alcohol. Before use, water was added to give ½ and ¾ pound of DDT in 2 gallons of spray.

To find a solvent for DDT that would be cheaper than the one used in 1950, and yet be satisfactory for the work, experiments were undertaken with various solvents available in the West. The mixture used in 1951 and 1953 consisted of 100 pounds of technical DDT, 40 gallons of aromatic solvent, and 90 ounces of the emulsifier used in 1950. This emulsion was used at the rate of about 0.6 pound of DDT in 1951 and about 0.85 pound in 1953 in approximately 2 gallons of spray per acre.

RESULTS

The weed-host areas sprayed and the results against the beet leafhopper obtained with pyrethrum in 1949 and with DDT in the other 3 years are shown in table 1. Also shown are the cost figures, which include insecticide materials, equipment depreciation, salaries, reimbursement accounts, gasoline, oil, and miscellaneous expenses.

Table 1.—*Effectiveness of pyrethrum and DDT in sprays against beet leafhoppers in weed-host areas of south-central Idaho*

Insecticide and period	Weed-host area	Leaf-hoppers per square foot	Mortal-ity	Cost per acre
Pyrethrum:	*Acres*	*Number*	*Percent*	
May 11 to June 3, 1949	2, 600	44	91	$2. 05
DDT:				
April 27 to June 30, 1950	15, 000	33	94	. 89
April 25 to June 6, 1951	6, 300	[1] 9	93	1. 30
May 8 to June 12, 1953	11, 350	85	98	. 86

[1] Exclusive of small nymphs.

EVALUATION OF THE CONTROL PROGRAM

In an experiment of this kind it is not feasible to leave unsprayed areas as checks, as the leafhoppers from such areas would move into the beanfields and thereby defeat the purpose of the spray program. It was therefore necessary to establish a method for evaluating the control program. In this method the observed curly-top incidence in beans is compared with the incidence that could be expected on the basis of the various conditions that would normally affect the curly-top incidence in the absence of the control program.

The factors that affect curly-top incidence are far too complex to be measured accurately by a yardstick that applies to all conditions and all parts of the areas affected simultaneously. However, the seven most important factors were selected and evaluated on the basis of records and observations made over the previous 13 years. From these evaluations, the following score card was developed for determining expected curly-top incidence:

Factor	0	1	2	3	4	5
Number of overwintered leafhoppers per 100 square feet.	0–6	7–15	16–24	25–33	34–42	43+
Host plant distribution and abundance. Suitability of hosts. Seasonal conditions. Synchronization of spring movement, etc.	Very poor	Poor	Fair	Good	Very good	Excel-lent
Expected peak of spring movement—number per sample.	0–3	4–6	7–9	10–12	13–15	16+
Number of viruliferous leafhoppers.	0–1	1–2	2–3	3–4	4–5	5+

Each year the conditions that affect curly top were scored, and the total score expressed as the percentage of the maximum score of 35—seven factors times the highest rating of 5. This is the percentage of bean plants that would be expected to be infected with curly top in the absence of control measures. The expected percentages in 1949–51 and 1953 are shown with the observed in table 2.

TABLE 2.—*Percentage of bean plants infected with curly top*

Insecticide and year	Snapbeans		Great Northern U. I. 123	
	Expected	Observed	Expected	Observed
Pyrethrum:				
1949	10. 6	12. 2	7. 6	4. 7
DDT:				
1950	16. 4	9. 6	11. 7	3. 6
1951	9. 0	3. 9	6. 1	1. 4
1953	11. 1	1. 9	8. 0	. 4

Studies in southern Idaho early in the spring of 1949 indicated that a moderate number of leafhoppers were expected to move from the breeding areas to the cultivated districts and that approximately 12,000 acres of weed-host areas should be sprayed. However, only 2,600 acres were sprayed with pyrethrum, and later studies of the beanfields showed that the percentage of plants infected with curly top was not below that expected.

Similar studies early in the spring of 1950 indicated that a very large number of spring migrants were expected to move into the cultivated areas, and all the conditions indicated an outbreak year. When approximately 15,000 out of 20,000 acres of heavily infested weed areas were sprayed with DDT, the number of bean plants infected was reduced below the expected disease incidence by 41 percent for snapbeans and 69 percent for Great Northern U. I. 123 beans.

A statement issued on April 25, 1951, showed that the expected number of beet leafhoppers that would move from the spring breeding areas into the cultivated districts was high. After the release of this statement, conditions became unfavorable for leafhopper production, and only about 6,300 acres of the weed-host plants were sprayed with DDT. Because of the low populations of spring-generation nymphs in other breeding areas, the spraying for the season was stopped. The percentage of snapbeans infected with curly top was very low in 1951.

Studies in March and April 1953 showed an average of 40 overwintered beet leafhoppers per 100 square feet of weed-host area compared with 30 for the preceding 12 years, but in general the weed hosts at that time were not favorable for producing a maximum population. Rains during the last few days of April resulted in additional germination of spring weed hosts, so that a larger acreage had to be sprayed. When about 11,350 out of 15,000 acres of the most heavily infested areas were sprayed with DDT, the incidence of curly top was reduced below the expected by 83 percent for snapbeans and 95 percent for Great Northern U. I. 123 beans.

In both 1949 and 1950 the acreage to be sprayed was limited by the equipment available and by the time during which operations could be conducted effectively. In 1953 it was also limited by available funds.

DISCUSSION OF THE CONTROL PROGRAM

In south-central Idaho high populations of beet leafhoppers and serious losses to curly top-susceptible crops occurred in 11 of the years between 1919 and 1947 and, judging from previous experience, would have occurred in 1950 and 1953 if 15,000 and 11,350 acres, respectively, of the most heavily infested spring breeding areas had not been sprayed. Moderate populations, averaging about eight leafhoppers per square foot, were present in sugar beet fields in 1938, 1940, 1945, and 1949, and probably would have occurred in 1951 if the areas had not been sprayed. Even populations of this size are followed by some loss from curly top to susceptible varieties of beans growing near the spring breeding areas. In such years some spraying of heavily infested spring weed hosts would be required to reduce the leafhopper populations below numbers injurious to snapbeans. On this basis, control operations in each of the 11 years would have been required on spring breeding areas ranging from 5,000 to 25,000 acres.

By destroying the beet leafhoppers in their weed-host areas in the spring, it is possible to protect the snapbean crop from serious curly-top infection in years when the beet leafhoppers are numerous.

SUMMARY

The beet leafhopper (*Circulifer tenellus* (Baker)) is the only known carrier of curly top disease, the most important factor limiting the growing of snapbeans for seed in south-central Idaho. During years when high populations of leafhoppers move from their spring breeding areas in the desert to the cultivated districts, growers of snapbeans for seed suffer severe losses.

Because of the seriousness of the problem, a project was undertaken in 1949 to determine whether this crop could be protected by destroying the leafhoppers in their spring breeding grounds before they moved into the cultivated areas. About 2,600 acres were sprayed with pyrethrum, but later studies of the beanfields showed that the incidence of curly top was not below the expected.

High populations of beet leafhoppers were present over large acreages of weed hosts in the springs of 1950 and 1953. In these respective years approximately 15,000 and 11,350 acres of heavily infested wild mustards were sprayed with DDT. The spray was applied with turbine blowers at rates ranging from 0.5 to 0.85 pound of DDT in 2 gallons of emulsion per acre. The populations were reduced 94 and 98 percent at costs of 89 and 86 cents per acre.

Factors affecting beet leafhopper abundance and curly-top incidence in southern Idaho were studied, and index figures of expected infection in snapbeans were established. As a result of spraying operations in 1950 and 1953, snapbean plants infected with curly top were reduced 41 and 83 percent below the expected incidence. Reductions of 69 and 95 percent were similarly obtained for Great Northern U. I. 123 bean plants.

The results of these studies demonstrate that, by destroying beet leafhoppers in their weed-host breeding areas in the spring before they move into the beanfields, it is possible to protect the snapbean seed crop from serious curly-top infection.

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